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Twenty Year Trends (1975–1995) in the Incidence, In-hospital and Long-Term Death Rates Associated With Heart Failure Complicating Acute Myocardial Infarction

A Community-Wide Perspective

Frederick A. Spencer, MD, Theo E. Meyer, MD, Robert J. Goldberg, PhD, Jorge Yarzebski, MD, MPH, Mark Hatton, MD, Darleen Lessard, MS, Joel M. Gore, MD, FACC

Worcester, Massachusetts

OBJECTIVES To describe from a population-based perspective, recent and temporal (1975–1995) trends in the incidence, in-hospital and postdischarge case-fatality rates of heart failure (HF) complicating acute myocardial infarction (AMI).

BACKGROUND Extremely limited data are available describing the incidence and case-fatality rates associated with HF complicating AMI from a community-wide perspective.

METHODS The medical records of 6,798 residents of the Worcester, Massachusetts metropolitan area with validated MI and without previous HF hospitalized in 10 annual periods between 1975 and 1995 were reviewed.

RESULTS The proportion of AMI patients developing HF during hospitalization declined between 1975–1978 (38%) and 1993–1995 (33%) ($p < 0.001$). After controlling for potentially confounding factors, the risk of developing HF declined progressively, albeit modestly, over time. In-hospital case-fatality rates of patients with AMI complicated by HF declined by approximately 46% between 1975–1978 (33%) and 1993–1995 (18%) ($p < 0.001$). Improving trends in hospital survival were observed after adjusting for potentially confounding prognostic factors. The one-year post-discharge mortality rate for hospital survivors of HF did not change over the 20-year period under study, even after controlling for additional prognostic characteristics.

CONCLUSIONS The results of this community-wide study suggest encouraging declines in the incidence and hospital death rates associated with HF complicating AMI. Continued efforts need to be directed towards the prevention of HF given the magnitude of this clinical syndrome. Efforts of secondary prevention are needed to identify and improve the treatment of patients with symptomatic left ventricular dysfunction following AMI given the lack of improvement in the long-term prognosis of these patients. (J Am Coll Cardiol 1999;34:1378–87) © 1999 by the American College of Cardiology

Heart failure (HF) occurring as an acute complication of myocardial infarction (MI) is relatively prevalent and is associated with increased short-term mortality. More than 30 years ago, Killip recognized the importance of prognosticating patients with acute myocardial infarction (AMI) according to increasing hemodynamic instability (1). Subsequently, a number of studies identified clinical signs of left ventricular failure during and immediately after AMI as important predictors of prognosis (2–7). The relatively recent and widespread availability of improved cardiac imaging techniques have allowed for more direct estimates of infarct size and left ventricular function. The increased use of these techniques may have contributed to a decreased emphasis of the prognostic importance of the clinical syndrome of HF in the setting of AMI. Recent advances in therapeutic interventions for both AMI and HF may have resulted in declines in the incidence and mortality rates of HF following AMI though limited data are available to support this claim. On the other hand, it is generally accepted that older patients with more comorbidities are being treated for AMI and HF which could, in turn, increase these rates. Due to changing patient demographic

From the Department of Medicine, Division of Cardiovascular Medicine, University of Massachusetts Medical School, Worcester, Massachusetts. This study was supported through funding provided by the National Heart, Lung, and Blood Institute (R01 HL35434).

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Abbreviations and Acronyms

ACE = angiotensin converting enzyme
AMI = acute myocardial infarction
CABG = coronary artery bypass grafting
CFR = case-fatality rate
CI = confidence interval
HF = heart failure
MI = myocardial infarction
SMSA = standard metropolitan statistical area

and clinical characteristics and development and application of improved therapeutic interventions for AMI, it is also uncertain whether HF complicating AMI carries the same clinical and prognostic significance it once did more than three decades ago. Virtually no data are available to describe recent and temporal trends in the incidence and mortality rates associated with HF complicating AMI, particularly from a community-wide perspective.

The purpose of this population-based study was to determine whether the incidence and clinical impact of HF complicating AMI has changed over a 20-year period of study (1975–1995). Data obtained from community-wide studies may be more generalizable to a broader spectrum of patients with HF and provide a more representative picture of the natural history of this clinical syndrome than data derived in the context of clinical trials in more restricted patient samples. In addition, given the encouraging results of recent randomized trials in the medical management of patients with HF, temporal trends in the treatment of patients with HF complicating AMI are presented.

MATERIALS AND METHODS

Residents of the Worcester, Massachusetts metropolitan area hospitalized with a primary or secondary discharge diagnosis of AMI [International Classification of Disease (ICD-9) code 410] from all 16 Worcester standard metropolitan statistical area (SMSA) hospitals during 1975, 1978, 1981, 1984, 1986, 1988, 1990, 1991, 1993 and 1995 comprised the study population. In addition, a random sample of records from related diagnostic rubrics in which the diagnosis of AMI might have occurred (e.g., ICD codes 411 and 412) was carried out during each of the years under study to identify potentially misclassified cases of AMI. All hospitals in the Worcester SMSA (1990 census population = 437,000) participated in this study. Fewer hospitals were included in recent years due to hospital closures, mergers, or conversion to chronic care facilities. The medical records of Worcester SMSA residents with a discharge diagnosis of AMI from these hospitals were individually reviewed and validated according to preestablished diagnostic criteria that have been previously described (8–10). In brief, these criteria included a clinical history of prolonged chest pain not relieved by rest or use of nitrates, serum enzyme level elevations in excess of the upper limit of normal as specified by the laboratory at each hospital, and serial electrocardiographic tracings during hospitalization showing changes in the ST segment or Q-waves typical of AMI. At least two of these three criteria needed to be satisfied for study inclusion. All autopsy-proven cases of AMI were included irrespective of the other criteria. Cases of perioperative associated AMI were not included.

For the periods under study, the complications of AMI were assessed on the basis of information available from clinical charts (11,12). Heart failure was regarded as present when there was clinical or radiographic evidence of pulmonary edema or bilateral basilar rales with an S_3 gallop.

This report is based on information about the 6,798 residents of the Worcester metropolitan area who satisfied the diagnostic criteria for AMI in the ten one-year periods examined and who did not have a history of HF. These ten study periods were aggregated into five periods for purposes of analysis as well as to coincide with changes in the medical management of patients with AMI. Among the study sample, 1,402 patients were hospitalized in 1975–1978, 1,439 in 1981–1984, 1,231 in 1986–1988, 1,259 in 1990–1991 and 1,467 in 1993–1995.

Data collection. The hospital records of patients with validated AMI were abstracted for demographic and clinical data including age, gender, clinical complications during hospitalization, MI order (initial or recurrent), MI type (Q-wave or non–Q-wave) and MI location (anterior or inferior/posterior). The approaches used to ascertain survival status after hospital discharge included a review of records for additional hospitalizations and a statewide and national search of death certificates. Some form of additional follow-up was ascertained for the vast majority (99%) of residents of the Worcester SMSA discharged from area-wide hospitals following AMI.

Data analysis. Differences in the distributions of demographic and clinical characteristics between patients with AMI according to the development of HF during the acute hospitalization were examined by using chi-square tests of statistical significance. The short-term prognosis in each period was examined by calculating in-hospital case-fatality rates (CFRs). The simultaneous effect of several potentially confounding variables that might influence the development of HF during the acute hospitalization, as well as in-hospital death rates associated with HF, was accounted for by means of a logistic multiple regression technique. Because of the observational, nonrandomized nature of this study, and because of our methods of data collection which did not allow us to determine whether a medical therapy or surgical intervention preceded or came after the occurrence of HF, we did not control for the use of coronary interventional procedures or medical therapies. Another reason we did not control for these practices is the difficulty of interpreting any observed adjusted estimates of association. Our approach to model building focused on the hypothesis that variations in the incidence of HF over time were the result of changes in

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Table 1. Characteristics of Patients With AMI According to Occurrence of Heart Failure: Worcester Heart Attack Study

Characteristic	HF Present (n = 2,558)	HF Absent (n = 4,240)	p Value
Age (yrs)			
<55	10.4	24.0	
55–64	19.0	26.7	
65–74	31.0	27.2	< 0.001
≥75	39.6	22.0	
Mean age (yrs)	70.4	63.9	< 0.001
Male	55.8	67.0	< 0.001
Medical history			
Angina (+)	27.8	22.6	< 0.001
Hypertension (+)	53.0	46.7	< 0.001
Stroke (+)	10.6	5.5	< 0.001
Diabetes (+)	27.4	18.7	< 0.001
AMI characteristics			
Initial	64.6	75.0	< 0.001
Anterior	54.6	40.7	< 0.001
Q-wave	59.4	53.8	< 0.001

AMI = acute myocardial infarction; HF = heart failure.

the demographic or clinical characteristics (or both) of the study sample. We recognize that these trends might also reflect improvements in the use of various approaches to care, and increasing use of these approaches, over the 20-year period under study. Logistic regression analysis was also used to examine time trends in one-year post-hospital discharge mortality according to the development of HF during the acute hospitalization while adjusting for the effect of several potentially confounding prognostic variables.

RESULTS

Characteristics of patients with HF complicating AMI. Patients with AMI who developed HF during hospitalization were older, were more likely to be female and were significantly more likely to have a history of angina, hypertension, stroke or diabetes as compared with AMI patients who did not develop HF. Their presentation was also more commonly a recurrent, anterior and Q-wave MI compared with those not developing HF (Table 1).

As might be expected, over the two decades under study, patients developing HF were increasingly older and sicker. The mean age of patients with HF increased by four years over the 20-year study period and patients developing HF during more recent periods were more likely to include those with a history of hypertension, stroke or diabetes. On the other hand, patients developing HF less frequently presented with an anterior or Q-wave MI over time (Table 2).

Management practices and temporal trends therein. Over the 20-year study period, medication use differed according to whether or not HF was present. Patients with HF were significantly more likely to have angiotensin converting enzyme (ACE) inhibitors and digoxin either maintained or initiated during the acute hospitalization as compared with patients without HF (Table 3). Patients with HF were also much more likely to be discharged on these therapies. Antiplatelet agents, beta-adrenergic blocking agents and calcium channel blockers were used less frequently in patients with MI complicated by HF as compared with those not developing HF during the acute hospitalization.

Table 2. Temporal Trends in the Characteristics of Patients With AMI Developing Heart Failure: Worcester Heart Attack Study

	Time Period					
Characteristic	1975/78 (n = 537)	1981/84 (n = 627)	1986/88 (n = 461)	1990/91 (n = 448)	1993/95 (n = 485)	p Value
Age (yrs) (%)						
<55	14.3	10.5	7.2	10.0	9.1	
55–64	22.9	21.4	17.8	17.0	14.4	
65–74	30.4	31.9	32.8	29.9	30.1	< 0.001
≥75	32.4	36.2	42.3	43.1	46.4	
Mean age (yrs)	67.9	69.8	71.7	71.1	72.1	< 0.001
Male (%)	57.0	60.0	52.3	53.4	54.4	0.075
Medical history (%)						
Angina	24.8	31.3	27.6	27.2	27.4	0.18
Hypertension	43.8	52.5	53.6	56.3	60.4	< 0.001
Stroke	6.5	8.5	12.6	12.5	14.0	< 0.001
Diabetes	25.0	24.4	28.0	28.8	32.4	0.03
AMI characteristics (%)						
Initial	65.9	62.5	67.7	65.6	61.9	0.26
Anterior	55.7	60.5	59.2	49.6	46.4	< 0.001
Q-wave	77.7	64.5	54.1	51.8	45.8	<0.001

AMI = acute myocardial infarction.

Table 3. Use of Therapies in Patients With Acute Myocardial Infarction According to Occurrence of Heart Failure: Worcester Heart Attack Study

	HF Present (n = 2,558)	HF Absent (n = 4,240)	p Value
Therapies Maintained or Initiated During Acute Hospitalization (%)			
ACE inhibitors*	42.8	13.4	< 0.001
Antiplatelet agents	36.7	47.6	< 0.001
Beta^{2+} blockers	37.7	55.5	< 0.001
CA blockers†	46.3	48.2	0.28
Digoxin	37.3	11.7	< 0.001
Thrombolytics†	21.2	27.6	< 0.001
Discharge Medications (%)			
ACE inhibitors*	28.5	9.3	< 0.001
Antiplatelet agents	24.0	36.8	< 0.001
Beta blockers	25.0	47.5	< 0.001
CA^{2+} blockers†	27.0	36.1	< 0.001
Digoxin	28.0	8.8	< 0.001
Procedures (%)			
Cardiac catheterization	18.0	20.7	< 0.01
CABG	2.3	1.9	0.28
PTCA†	6.8	8.6	< 0.04

*Data available for the period 1990–1995; †Data available for the period 1986–1995.
HF = heart failure.

There were marked changes over time in the use of certain medications (Fig. 1) and coronary revascularization procedures (Fig. 2) in the study sample. The use of beta-blockers increased steadily over time in patients with and without HF, though utilization rates remained lower in the HF group overall as well as during each period under study. The use of antiplatelet agents increased in patients with and without HF. Use of digoxin also increased over time with use being nearly 3–4 times greater in patients with as compared with those without HF. Angiotensin converting enzyme inhibitors were used in an approximately similar ratio in patients with as compared with those without HF during 1993–1995. In the two most recent study years, approximately 27% of patients developing post-MI HF received thrombolytics compared with 31% of patients without HF.

Cardiac catheterization was performed more frequently in patients without HF though by the most recent study period these rates were relatively comparable in patients with (41%) and without HF (39%). Rates of coronary artery bypass grafting (CABG) remained low in both groups reaching highs of 7% in the HF group and 4% in the non-HF group in 1993–1995. Coronary angioplasty was used in approximately 15% of AMI patients, irrespective of occurrence of HF, in 1993–1995.

Incidence rates of HF complicating AMI. Heart failure developed in approximately 38% of patients with validated AMI over the 20-year study period. As noted previously, we aggregated the ten individual study years into five periods to make trends in the proportion of AMI patients developing HF more interpretable as well as to coincide with changes in the management of patients with AMI. A decline in the crude unadjusted incidence rate of HF was noted between 1975–1978 and 1993–1995 though increases in these rates were noted during the initial study years (Table 4).

Given changes in patient demographic, medical history and clinical characteristics over the two decades of this study, we examined trends in the risk of developing HF after adjusting for age, gender, comorbid conditions (history of angina, diabetes, hypertension or stroke) and AMI associated characteristics (Table 4). After adjusting for age and gender only, the odds of developing HF decreased progressively and significantly over time with the lowest observed risk seen during the most recent period of hospitalization. In 1993–1995, AMI patients were at approximately one-third lower risk for developing HF than patients hospitalized with AMI in 1975–1978. The multivariable adjusted odds of developing HF also declined over the 20-year study period though the decrease in risk was attenuated after controlling for additional comorbidities and AMI associated characteristics.

In-hospital case-fatality rates. The in-hospital case-fatality rate for patients with HF declined significantly over time from 32.6% during 1975–1978 to 17.7% in 1993–1995 ($p < 0.001$). The short-term case fatality rates for AMI patients without HF remained relatively stable at approximately 7% to 9% for this period (Fig. 3).

The age, gender and multivariable adjusted odds of dying following HF declined progressively over time (Table 5). Compared with patients hospitalized approximately 20 years earlier, the risk of dying following the development of HF declined by approximately 60% depending on the covariates adjusted for with particularly marked declines in hospital mortality observed during the 1990s. Despite these

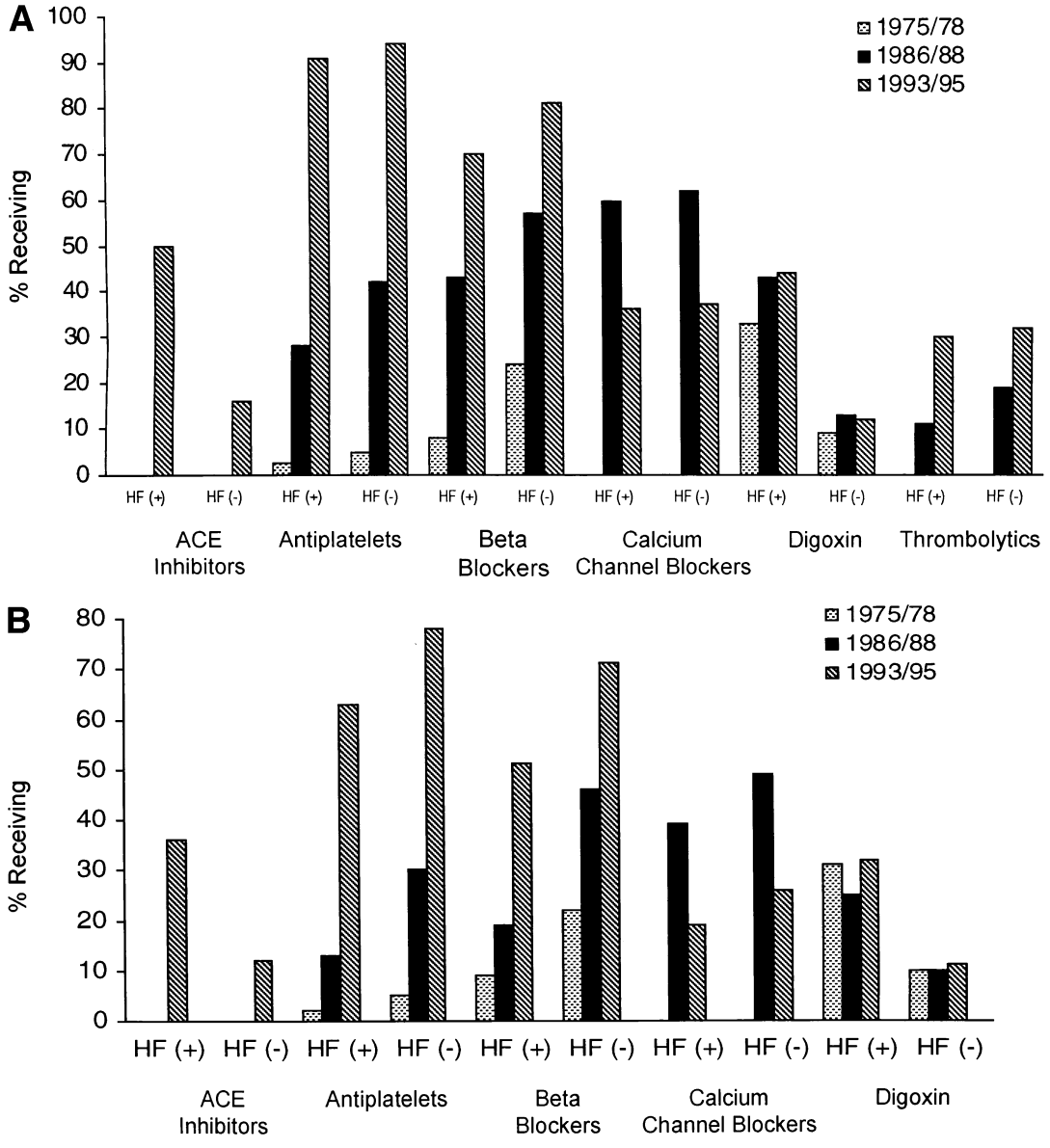

Figure 1. (A) Trends in the use of cardiac medications maintained or initiated during hospitalization according to presence of heart failure (HF) complicating acute myocardial infarction: Worcester Heart Attack Study. **(B)** Trends in the use of cardiac medications at the time of hospital discharge according to presence of HF complicating acute myocardial infarction: Worcester Heart Attack Study.

impressive declines in hospital death rates, patients with HF remained at significantly greater risk for dying than patients without HF. Over the entire study, the multivariable adjusted odds of dying from HF (as compared with those without HF) was 2.71 (95% confidence interval [CI] = 2.31, 3.18).

We carried out an additional analyses in which the characteristics of patients with HF who survived the acute hospitalization were compared with those who died, overall as well as during the most recent study years (Table 6). Patients developing HF during the mid-1990s were specifically studied to determine whether or not the profile of patients dying from HF had changed during recent years. Patients surviving HF were significantly younger, less likely to have a history of stroke, more likely to experience an inferior/posterior, non–Q-wave AMI and were more likely to be treated with each of the medications under study. Similar findings were observed in contrasting the characteristics of hospital survivors of HF in 1993–1995 as compared with those who did not survive the acute hospitalization. While an increasingly greater proportion of patients developing HF were treated with each of the therapies examined during the mid 1990s, with the exception of calcium channel blockers whose overall use declined, patients surviving HF in the mid 1990s were significantly more likely to be treated with ACE inhibitors, antiplatelet

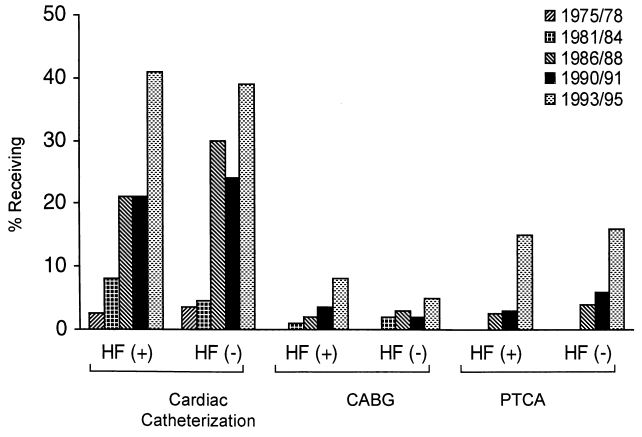

Figure 2. Trends in the use of coronary revascularization procedures according to presence of heart failure (HF) complicating acute myocardial infarction: Worcester Heart Attack Study.

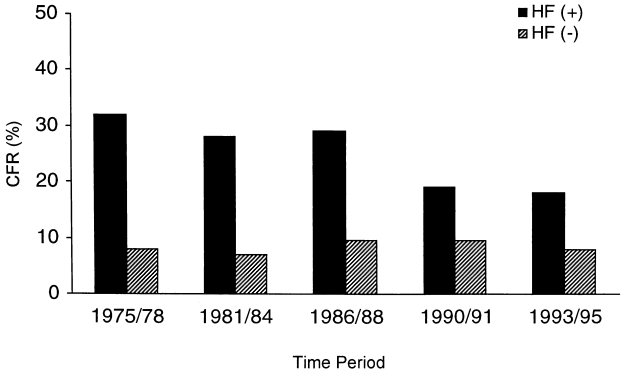

Figure 3. Trends in hospital case fatality rates (CFR) according to the presence of heart failure (HF) complicating acute myocardial infarction: Worcester Heart Attack Study.

agents, beta-blockers and thrombolytic therapy than HF patients who did not survive the acute hospitalization.

Long-term survival. Given declining hospital death rates among patients with HF, we examined trends in post-discharge survival associated with HF occurring during the acute hospitalization to determine whether or not survival patterns following hospital discharge had similarly improved. For this analysis, we examined the risk of dying during the first year following hospital discharge given the marked increase in death rates during this period and the abbreviated long-term follow-up available for those hospitalized in the most recent cohort. The cumulative one-year mortality for patients with AMI complicated by HF did not change over time (Fig. 4). The one-year mortality rates were 20.7% for patients discharged in 1975–1978, 21.3% for those discharged in 1986–1988 and 21.1% for those discharged in 1993–1995.

Since the demographic, medical history and clinical characteristics of patients discharged from area-wide hospitals following AMI may have changed over time, we examined trends in one-year death rates among patients with HF while controlling for these covariates. After adjusting for age and gender only, compared with patients discharged in 1975–1978, the adjusted odds of dying within the first year following hospital discharge for HF were 1.33 (95% CI = 0.96, 1.86) in 1981–1984, 0.85 (95% CI = 0.59, 1.24) in 1986–1988, 1.06 (95% CI = 0.74, 1.52) in 1990–1991 and 0.80 (95% CI = 0.56, 1.15) for patients discharged in 1993–1995. After controlling for these demographic characteristics plus previously described medical history and clinical characteristics, the multivariable adjusted odds of dying during the first year following hospital discharge also exhibited inconsistent trends over time. These adjusted risks of dying were 1.28 (95% CI = 0.90, 1.83) in 1981–1984, 0.81 (95% CI = 0.54, 1.21) in 1986–1988, 1.05 (95% CI = 0.72, 1.53) in 1990–1991 and 0.76 (95% CI = 0.52, 1.12) in 1993–1995 in comparison with patients discharged in 1975–1978.

Table 4. Time Trends in the Multivariable Adjusted Odds of Developing Heart Failure in Patients With AMI: Worcester Heart Attack Study

Time Period	% Developing HF	Crude Odds Ratio	Adjusted for Age and Gender	Multivariable Adjusted Odds Ratio*
1975/78	38.3	1.0	1.0	1.0
1981/84	43.6	1.24 (1.07, 1.45)†	1.15 (0.99, 1.35)	1.20 (1.02, 1.41)
1986/88	37.5	0.96 (0.82, 1.13)	0.86 (0.73, 1.01)	0.92 (0.77, 1.09)
1990/91	35.6	0.89 (0.76, 1.04)	0.76 (0.65, 0.90)	0.89 (0.75, 1.05)
1993/95	33.1	0.80 (0.68, 0.93)	0.67 (0.57, 0.78)	0.81 (0.69, 0.96)

*Adjusted for age, gender, comorbid conditions, AMI order, AMI type and AMI location. †95% CI.
AMI = acute myocardial infarction; CI = confidence interval; HF = heart failure.

Table 5. Time Trends in the Multivariate Adjusted Odds of Dying in Hospital Following Heart Failure Complicating AMI: Worcester Heart Attack Study

Time Period	% Dying	Crude Odds Ratio	Adjusted for Age and Gender	Multivariable Adjusted Odds Ratio*
1975/78	32.6	1.0	1.0	1.0
1981/84	26.0	0.73	0.66	0.73
		(0.56, 0.94)†	(0.51, 0.86)	(0.55, 0.96)
1986/88	27.8	0.80	0.68	0.80
		(0.61, 1.04)	(0.51, 0.89)	(0.59, 1.08)
1990/91	19.9	0.51	0.43	0.52
		(0.38, 0.69)	(0.32, 0.59)	(0.38, 0.71)
1993/95	17.7	0.45	0.36	0.46
		(0.33, 0.60)	(0.27, 0.49)	(0.33, 0.63)

*Adjusted for age, gender, comorbid conditions, AMI order, AMI type and AMI location. †95% CI.
AMI = acute myocardial infarction; CI = confidence interval.

DISCUSSION

The results of the present analysis from the Worcester Heart Attack Study suggest encouraging declines in the incidence rates of HF complicating AMI and significant improvements in hospital survival following AMI complicated by HF. Inconsistent and nonsignificant trends in post-discharge survival were seen among patients discharged from greater Worcester hospitals following HF during the most recent study years.

Incidence rates of HF. There is a paucity of studies that have described the incidence rates of HF complicating AMI and limited data are available describing temporal trends in the risk of developing HF in the setting of AMI. Separate studies of hospitalized patients with AMI conducted from

Table 6. Characteristics of Patients With AMI Complicated by Heart Failure Surviving and Not Surviving the Acute Hospitalization: Worcester Heart Attack Study

	Total Sample			1993/95 Cohort		
Characteristic	Survived (n = 1,917)	Died (n = 641)	p Value	Survived (n = 399)	Died (n = 86)	p Value
Age (yrs)						
<55	12.4	4.4		10.3	3.5	
55–64	20.5	14.5	< 0.001	15.8	8.1	< 0.001
65–74	32.0	28.1		30.0	30.2	
≥75	35.2	53.0		43.9	58.1	
Male	56.8	52.6	0.06	55.4	50.0	0.36
Medical History						
Angina	27.9	27.6	0.91	28.3	23.3	0.34
Hypertension	54.0	50.1	0.09	60.2	61.6	0.80
Stroke	9.8	12.8	< 0.05	12.5	20.9	< 0.05
Diabetes	28.1	25.6	0.22	33.3	27.9	0.33
AMI Characteristics						
Initial	65.2	62.9	0.30	62.4	59.3	0.59
Anterior	53.0	59.1	< 0.01	46.4	46.5	0.98
Q-wave	55.5	71.2	< 0.001	43.1	58.1	< 0.025
Therapy*						
ACE inhibitors	44.7	34.3	< 0.025	51.6	39.5	< 0.05
Antiplatelets	42.5	19.5	< 0.001	93.0	81.4	< 0.001
Beta blockers	44.6	17.0	< 0.001	75.9	41.9	< 0.001
CA^{2+} blockers	48.8	37.6	< 0.001	37.3	26.7	0.06
Digoxin	41.8	23.9	< 0.001	45.1	43.0	0.72
Thrombolytics	23.3	13.5	< 0.001	29.3	18.6	< 0.05

*Maintained or initiated during hospitalization.
AMI = acute myocardial infarction.

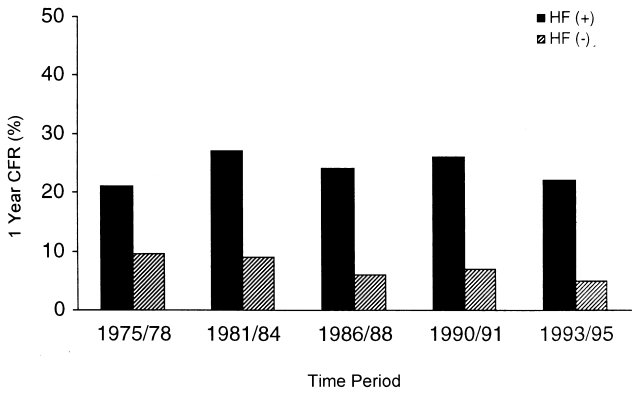

Figure 4. Trends in one-year case-fatality rates of discharged hospital patients according to presence of heart failure (HF) complicating acute myocardial infarction: Worcester Heart Attack Study.

1979 to 1981, 1974 to 1984 and 1986 to 1987 identified HF in 48%, 41% and 51% of patients respectively (7,13,14). A more recent trial, the Acute Infarction Ramipril Efficacy Study, screened nearly 31,000 patients with AMI from 144 participating trial centers over the period 1989–1992; 45% of study patients had evidence of HF (15). While the results of these different studies in varying patient samples suggest no improvement over time in the incidence rates of HF complicating AMI, extrapolation of these results to a community-based sample of patients with HF is tenuous and fraught with difficulties in interpretation. This is because of differences in the characteristics of the study populations, working definitions of HF and AMI and treatment approaches that were used which may have affected the risk of developing HF.

Reasons for the declining incidence rates of HF observed in the present population-based study are not readily apparent. While patients developing HF over the 20-year study period were older and were more likely to have serious comorbid conditions present, the proportion of AMI patients experiencing HF nonetheless declined, with these declines being most marked during the 1990s. While it is possible that trends in the incidence rates of HF may reflect changes in patient clinical characteristics, such as a declining proportion of patients with Q-wave infarcts, control for these and additional potentially confounding variables was carried out to analytically adjust for these changing patient characteristics over the 20-year study period. Changes over time in the incidence as well as death rates associated with HF may also reflect inadequate measurement of, or failure to measure, additional covariates that might affect the risk of developing, or dying from, HF. These encouraging trends likely reflect the increasing use of preventive and aggressive therapeutic strategies directed at patients at high risk for developing HF with the end result of declining incidence.

Hospital death rates associated with HF. Declines in the unadjusted hospital case-fatality rates for AMI patients developing HF were observed between 1975 and 1995. These declines became even more pronounced after multivariable adjustment for additional prognostic confounders, including the advancing age of study patients and presence of comorbid conditions. Relatively little change was observed in the hospital death rates of AMI patients who did not develop HF.

Over the last two decades numerous studies, especially those assessing the efficacy of coronary reperfusion approaches, have documented steadily decreasing hospital death rates following AMI (16–19). However, none of these studies specifically examined changes over time in hospital mortality associated with HF complicating AMI. To the best of our knowledge, this is the first community-based study that has examined changes over time in hospital mortality associated with HF, documenting a consistent decline in short-term mortality in patients with this clinical syndrome. In previous publications from the Worcester Heart Attack Study we have demonstrated declining hospital death rates associated with AMI (10,20), including an earlier report from this study that examined trends in hospital mortality in patients with HF (21). It is important to note, however, that the development of HF as recently as 1993–1995 was still associated with an increased risk of dying in comparison with those not suffering HF. As such, a diagnosis of HF in the setting of AMI retains its importance as a prognostic indicator of a poor outcome.

Furthermore, the present results suggest that deaths among patients with HF may be preventable, or at least postponed, as subgroups at increased risk for dying following HF were identified. In particular, the elderly, patients with a history of stroke and those with a more extensive AMI were more likely to die from HF than respective comparison groups. In addition, patients dying after HF were significantly less likely to be treated with agents shown to be effective in the management of AMI. While we did not adjust our study findings for the increasing use of effective cardiac therapies (given the nonrandomized nature of the present study), these data provide encouragement for the increasing effectiveness of modalities designed to reduce infarct size, prevent recurrent myocardial ischemia and favorably alter left ventricular remodeling. Our results suggest that further intervention efforts should be directed to these high risk patients with the goals of improving survival in patients with HF following AMI.

Long-term survival following HF. Few studies have described mortality following hospital discharge for patients with HF complicating AMI. In addition, we were unable to identify any studies describing temporal trends in long-term mortality among AMI patients developing HF. A small study of 39 survivors of AMI with pulmonary edema conducted in 1981 documented a 29% mortality rate over the ensuing nine months (22). In a study of 440 AMI patients with HF seen at a single hospital from 1986–1987, the one-year mortality was 39% (14). Analysis of screening

data from the Trandalopril Cardiac Evaluation Study (1990–1992) revealed an approximate 43% one-year mortality in AMI patients with HF (23). When assessed chronologically, despite the caveats involved in extrapolating from different studies carried out in different settings and study samples, these studies fail to reveal any patterns of improvement in the one-year mortality rates of this high risk subset of patients.

These trends are in agreement with the findings of this study in which no discernible trends in one-year mortality following hospital discharge for HF were observed. Patients experiencing AMI complicated by HF during recent study years were increasingly older and more likely to have significant comorbidities present than patients hospitalized in the 1970s and 1980s; this may explain, in part, why the long-term prognosis following HF has not improved over time despite the more widespread application of more effective treatment approaches. It is interesting that, even after adjustment for age, gender and comorbidities, no improvement in long-term outcome following HF was discernible over the last 20 years. These findings highlight the important prognostic influence of HF following AMI. Lack of improvement over time in the long-term outlook of these patients may also reflect the underutilization or underdosing of effective cardiac therapies presently available, poor patient compliance or other features associated with the natural history of HF.

This study was carried out in a well-defined metropolitan area whose sociodemographic and economic characteristics reflect those of the U.S. population as a whole with the exception of race as the vast majority of Worcester SMSA residents are white. Strengths of this study are the large sample size, its population-based perspective enhancing the generalizability of study findings and inclusion of all area-wide hospitals. This study has several limitations: specific therapy for patients with HF was not determined by a standardized study protocol but by the many physicians practicing at area-wide hospitals. In addition, given the method of data collection and recording of hospital data, it was difficult to determine whether a particular drug or interventional procedure was used before or after the development of HF. Due to our methods of data collection, we were unable to determine changes in patients' clinical status following hospital discharge.

In summary, the results of this population-based study suggest that, coincident with the increasingly aggressive management of AMI, the incidence of HF has decreased significantly in the last 20 years. Furthermore, while the hospital prognosis associated with HF following AMI has consistently improved over time, the one-year mortality rate of hospital survivors of HF has not been favorably altered. These findings reinforce the continued attention that needs to be devoted to the early identification of patients at increased risk for this syndrome and the application of timely and effective preventive and treatment strategies. In addition, it remains necessary to use the full complement of effective secondary prevention approaches in patients developing left ventricular failure in the setting of AMI given their impaired hospital and long-term prognosis compared with patients not developing HF.

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Reprint requests and correspondence: Dr. Robert J. Goldberg, Department of Medicine, University of Massachusetts Medical School, 55 Lake Avenue, North Worcester, Massachusetts 01655.

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